Enabling data-sharing:

Emerging principles for transforming urban mobility

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With thanks and recognition to all members who have contributed to this paper

Executive summary

The landscape of urban mobility is changing. The change is driven by many issues: urbanization and socio-economic shifts; increasing concerns around resiliency; citizen engagement; digital disruption and shifting customer needs.

Mobility infrastructure and business models are adapting to the new environment. In recent years, we've seen the rapid growth of ride-hailing and ride-sharing; the maturing of powertrain technologies; lightweight and smart materials for vehicles; shifts in mobility preferences; and the deployment of connected cars. Soon, there will be autonomous vehicles on the roads.

The option to plan a truly integrated multi-modal trip (that is, single ticketing and payments across a range of transport vehicles and routes) is closer than ever for the global consumer. Consumers are increasingly aware of the societal and environmental impacts of their mobility choices and they are beginning to favor options that are more convenient and more sustainable.

To optimally realize this change, mobility needs a shared digital framework that allows aggregation of new sources of data from connected infrastructure and vehicles, smartphones and more. This framework can, in theory, provide a detailed, high-fidelity and almost real-time picture of the urban environment.

It is certain that data will form the nervous system of this inter-connected mobility ecosystem and unlock an array of opportunities and benefits.

For example, by integrating real-time data from smartphones, connected vehicles and smart infrastructure, public safety officials can respond more quickly to crashes or other emergencies, using live traffic data to identify the quickest route to the scene. The same traffic and navigation app can be used to redirect other travelers away from the incident and traffic light systems can respond to the data and events by creating a "green wave" of uninterrupted but safe transit for first responders.

By integrating pick-up and drop-off data from ride-hailing providers and last-mile delivery companies, along with traffic flow, parking and pedestrian information, private sector providers can work with city authorities to dynamically manage curbsides to improve throughput, reduce dwell times and improve congestion.

Equally, the true potential value of data-sharing is largely unknown. New applications and new sources of value are sure to emerge as different streams of data are aggregated, analyzed and processed.

However, the collection and use of data like this also comes with a unique set of challenges and risks – not just for the individuals and entities to whom the data corresponds, but to the organizations and utilities who access, store and share it.

Many entities may be averse to sharing data, for reasons including real and perceived competition, privacy and ethics, the regulatory environment, cybersecurity, interoperability and liability.

Overcoming these challenges means finding alignment between multiple actors including citizens, governments, businesses and civil society.

The data-sharing principles workstream of WBCSD's Transforming Urban Mobility project aims to create common ground between stakeholders, by developing a shared understanding of the problem and defining a set of principles that can shape a model and standards for data-sharing.

Working in partnership with a range of mobility stakeholders including auto manufacturers, operators and industry experts, we have identified the following principles for data sharing as best practice:

1. Data-sharing should enable all stakeholders to create and capture value
2. Data-sharing must be ethical, inclusive and unbiased
3. Data-sharing should incorporate privacy by design
4. Data-sharing should embrace cyber-security by design
5. Data-sharing should be adaptive and iterative

It is expected that these emerging principles will evolve in parallel beside the broader mobility landscape, societal expectation and the regulatory environment. Pilots and demonstration projects of use-cases will also provide new learnings and evidence to revisit these principles.

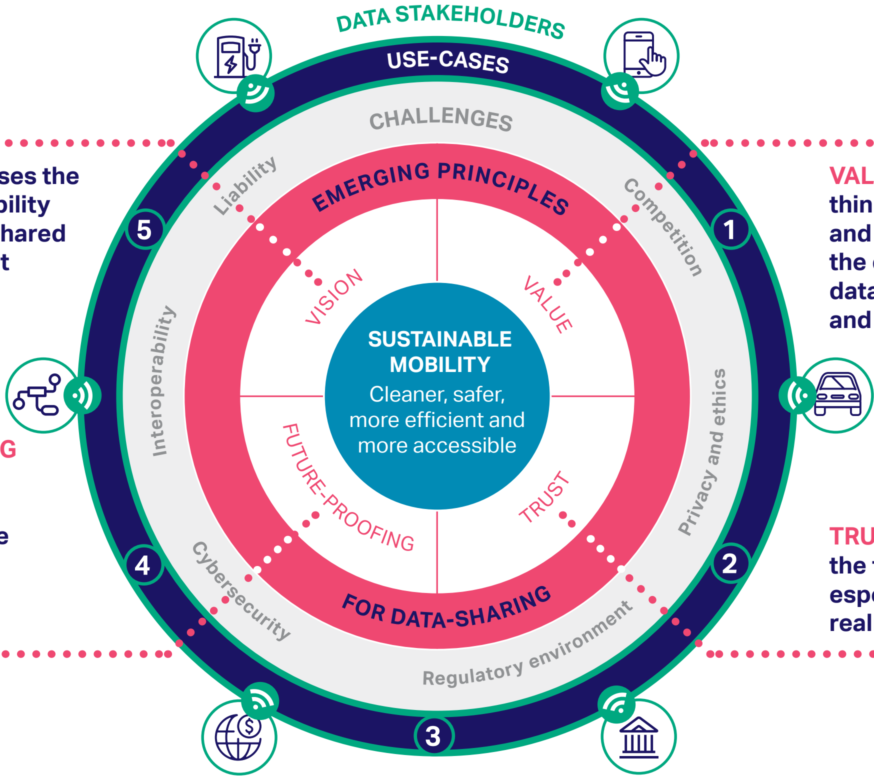
MOBILITY DATA-SHARING PRINCIPLES

CONTEXT

- Global urban **passenger-miles will double** across all modes by 2050.
- There is an estimated **USD $1 trillion shortfall in global transportation infrastructure** spending.
- In the most **congested cities**, **drivers spend** between 100 and 200-plus hours per year **– two to five entire workweeks – stuck in traffic**.
- The cumulative impact on US GDP of **deteriorating infrastructure could exceed USD $500 billion** annually by 2040.
- Based on data from roughly 3,000 cities, nearly **80 percent of people living in urban areas are exposed to air pollution –** much of it attributable to vehicle emissions, increasing the risk of a variety of respiratory diseases, heart disease, stroke and lung cancer.

VISION encompasses the end-goal for a mobility use case and the shared data that enables it

FUTURE-PROOFING entails crafting principles that are sufficiently flexible to cope with a rapidly changing environment



VALUE means thinking expansively and holistically about the different ways data creates benefits and for whom

TRUST is essential to the future of mobility, especially in the realm of shared data

EMERGING PRINCIPLES FOR DATA-SHARING

1. Data-sharing should enable all stakeholders to create and capture value
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USE-CASES

1. Integrated mobility platform incorporating multi-modal transportation systems
2. Real-time management and optimization of fleets
3. Improving access to mobility for low-income populations
4. Targeted infrastructure redesign and redevelopment to address road bottlenecks
5. Electric vehicle use via transportation network companies

In this report, we have taken a system-wide approach that considers how these principles can overcome the limitations of all affected actors, including governments, business and citizens. They are based on best-case evidence from global case studies and diverse stakeholder inputs.

The principles were qualified through a detailed study based on a broad set of mobility use-cases. We have validated these emerging principles and demonstrated how they will have a direct impact.

These use-cases demonstrate the public and private value of data-sharing in urban mobility systems. Their implementation provides a common framework for cooperation and help steer urban mobility systems towards a cleaner, safer, more accessible and more efficient future.

These use-cases include:

a. Integrated mobility platforms incorporating multi-modal transportation systems

b. Real-time fleet management and optimization

c. Improving access to mobility for low-income populations

d. Targeted infrastructure redesign and redevelopment to address road bottlenecks

e. Electric vehicle use via transportation network companies.

The five principles will serve as the foundational elements for implementation of these and other use-cases in urban mobility systems. It is our view that these principles could be directly applied to test and develop future data-sharing models, frameworks and agreements which dictate the conditions and constraints for data exchange.

Collaborative action will underpin data-sharing towards realizing a sustainable urban mobility future. We hope that all stakeholders will find these principles a useful starting point as they work to advance the future of mobility.

1 The challenges of urban mobility[1]

Many big cities in the world are struggling to meet the mobility needs of their citizens. Fueled by population growth, urbanization, misaligned transportation systems and a shortfall in investment in public infrastructure, transportation challenges such as congestion, inefficiency and pollution are having a detrimental effect on urban life.

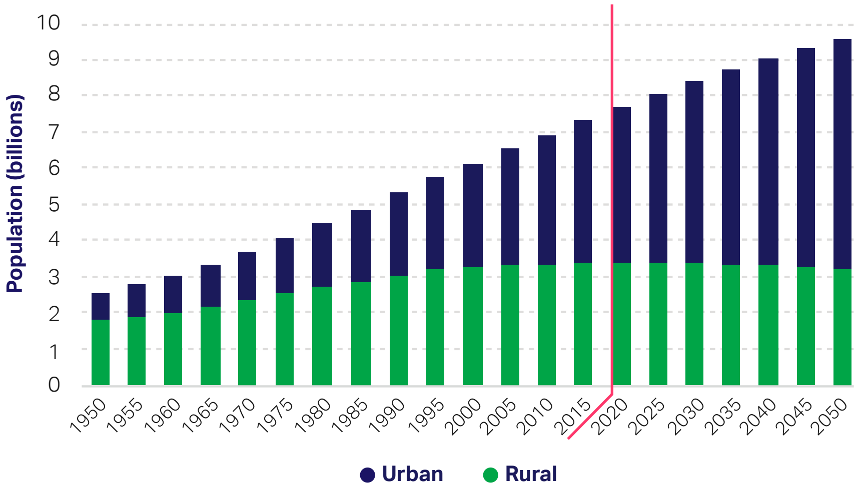
Urban populations have grown steadily since 1950 (see figure 1).[2] Today, roughly four billion people live in urban areas, a number the United Nations expects to reach more than six billion by 2050 – two out of every three people on earth.[3]

While most cities are relatively small, more than 500 are home to at least a million people. By 2030, there could be 41 "megacities" with populations of more than 10 million; there are already 11 such cities in China and India alone.[4]

Analysts expect the demand for city mobility to increase accordingly, with global urban passenger-miles estimated to nearly double by 2050 (see figure 2).[5] In most cities, public infrastructure and transit systems simply cannot keep pace with the growth. There is already an estimated USD $1 trillion shortfall in global infrastructure spending.[6]

Based on expected population and economic growth and in the absence of major policy and technological changes, by 2050 approximately 24 million additional kilometers of paved roads and 30,000 square miles of parking space could be needed to meet this global demand.[7]

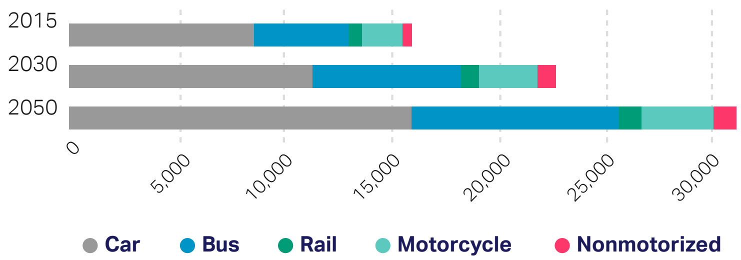
Figure 1: Global urban and rural population, 1950-2050



Source: United Nations Department of Economic and Social Affairs, Population Division, *World urbanization prospects: The 2014 revision*, 2015.

The world's population is steadily becoming more urban. **30%** of the world's population was urban in **1950**. **By 2050**, that proportion will rise to **66%.**

Figure 2: Urban passenger-miles by mode (billions)



Source: International Transport Forum, *ITF Transport Outlook 2017* (Paris: OECD Publishing, 2017)

By 2050, global urban passenger-miles will almost **double.**

Many cities are already experiencing the downsides associated with overloaded and inefficient road and transit systems. In the most congested cities, drivers spend between 100 and 200-plus hours per year (two to five entire workweeks) stuck in traffic.[8] For example, the cumulative impact on US GDP of deteriorating infrastructure could exceed USD $500 billion annually by 2040.[9] Likewise, four of India's biggest cities – Bengaluru and Chennai, Delhi and Mumbai – may be losing up to USD $22 billion annually due to traffic congestion.[10]

Congestion is perhaps the most visible symptom of cities' mobility-related challenges, but it is by no means the most serious. Based on data from roughly 3,000 cities, nearly 80 percent of people living in urban areas are exposed to air pollution – much of it attributable to vehicle emissions[11] – that exceeds World Health Organization recommendations. This increases the risk of respiratory diseases, heart disease, stroke and lung cancer.[12] In OECD countries alone, more than seven million years of life were lost due to ambient air pollution in 2010, about 50 percent of which comes from road transit.[13] In major US urban areas, the annual health costs of congestion exceed USD $30 billion.[14]

The act of commuting itself is associated with poorer health outcomes.[15] And yet research suggests that access to transportation is one of the most important factors for escaping poverty in cities.[16]

2 The future of mobility

Amidst these challenges, the entire way that people and goods travel from point A to point B is changing. This is being driven by converging technological and social trends: the rapid growth of car-sharing and ride-sharing; the increasing viability of electric and alternative powertrains; new, lightweight materials; and the growth of connected and, ultimately, autonomous vehicles.

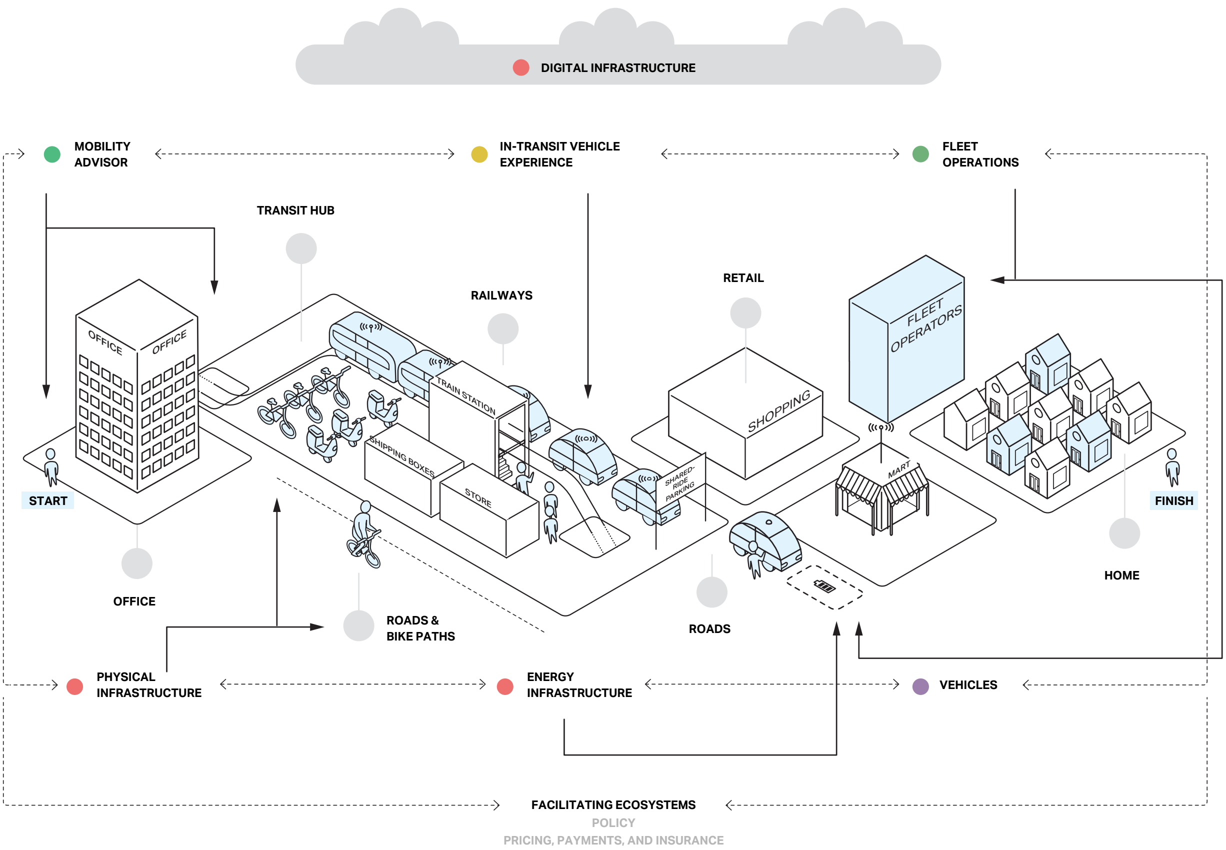
In just the last several years we have seen significant advances in:

- **Trip planning and as-a-service mobility models,** including multi-modal journey planning, integrated payments and ticketing, wayfinding, ride-hailing, car-sharing, and micro-transit. A number of cities, including Helsinki, Los Angeles, Paris and Singapore, are experimenting with mobility-as-a-service, which relies on "a digital platform that integrates end-to-end trip planning, booking, electronic ticketing, and payment services across all modes of transportation, public or private."[17] It also encompasses integrated payments and ticketing: the ability to pay for an entire multi-modal trip with a single charge (unified payment), which directly incentivizes multi-modal transportation. Interest in surge and use-based pricing is also growing.
- **Smart infrastructure and vehicle-to-everything connectivity** that can balance traffic loads through smart traffic lights and individual route optimization; reduce the number of accidents, for example, through vehicle connectivity and smart crosswalks; lower electrical consumption via smart street lights; monitor air quality and also service a growing fleet of electric vehicles through electric charging stations.
- **New modes of mobility** – notably, micro-mobility. Electric scooter services, in particular, have stormed the market since their introduction just a few years ago, in some cases creating friction with local authorities. Adoption rates have been impressive, surpassing those seen by popular ride-hailing applications during their early days.[18] Others have moved quickly into this space, with major ride-hailing providers and automakers investing in the micro-mobility spectrum.
- **Use of urban space** including smart curbs, smart metering and smart parking. There could be more than one million on-street smart parking spaces globally by 2026, reducing the congestion and pollution associated with "cruising" for a vacant space.[19]
- **The shift in vehicle powertrains** driven by technological advances, lower battery costs, environmental concerns and regulatory pressure. Volkswagen aims to sell a million electric cars annually by 2025, with 80 battery or hybrid vehicles; other automakers have similarly ambitious plans.[20] Hydrogen-powered vehicles show promise for freight applications.[21] By 2040, more than half of new passenger vehicles sold and nearly one-third of the entire on-road fleet could be electric.[22]
- **Autonomous vehicles** may be further from widescale deployment than previously believed,[23] but in-market pilots continue to advance and the first truly driverless service (without a safety driver) took place in late 2019. Beyond fleets of shared autonomous ride-hailing vehicles in cities, we are likely to see self-driving shuttles, delivery robots and other applications come to market in the next few years.

As these changes and others – from autonomous drones and flying cars to Hyperloop – unfold, the result is the emergence of a new mobility system that could offer faster, cheaper, cleaner, safer, more efficient and more customized travel (see figure 3).

However, realizing these benefits will depend on how the system is deployed and governed.

Figure 3: The future of mobility



Source: Scott Corwin, et al., *The future of mobility: What's next?*, Deloitte Insights, September 2016.

3 Data-sharing in the future of mobility

Deploying uncoordinated and isolated technology solutions and services is likely to leave many system-wide benefits unrealized. They could exacerbate a city's mobility challenges rather than easing them.

Transportation network company services have already added 5.7 billion miles of driving in the nine largest cities in the US.[24] New modes of mobility interact with existing public transit in complex ways, and in some cases, could cannibalize usage or fail to serve the people who need them most.[25]

In New York City for example, nearly half of all ride-hailing trips replace transit, according to the city's surveys.[26] At a minimum, some level of coordination and optimization is critical if existing system challenges are not to be amplified. Both of those efforts require the use of data between multiple stakeholders.

Shared data will be the nervous system of this complex, interconnected mobility system.

Digital information from phones, connected vehicles, smart infrastructure and more is already collected and stored by a host of government and private sector entities. Today, the innovative use of this data underpins some of the most successful and disruptive mobility businesses, from ride-hailing and micro-transit to intelligent transportation systems.

To date, many of those businesses have been able to leverage existing open source data, such as public transit application program interface (APIs), or they have been built using their own customer and other data (such as ride-hailing apps).

A myriad of new applications become possible when mobility data can be exchanged. By integrating real-time data from smartphones, connected vehicles and smart infrastructure, public safety officials can respond more quickly to vehicle accidents or other emergencies, using live traffic data to identify the quickest route to the scene.

The same traffic and navigation app can be used to redirect traffic away from the incident, and traffic light systems can respond to the data and events by creating a "green wave" of uninterrupted but safe transit for the responders.

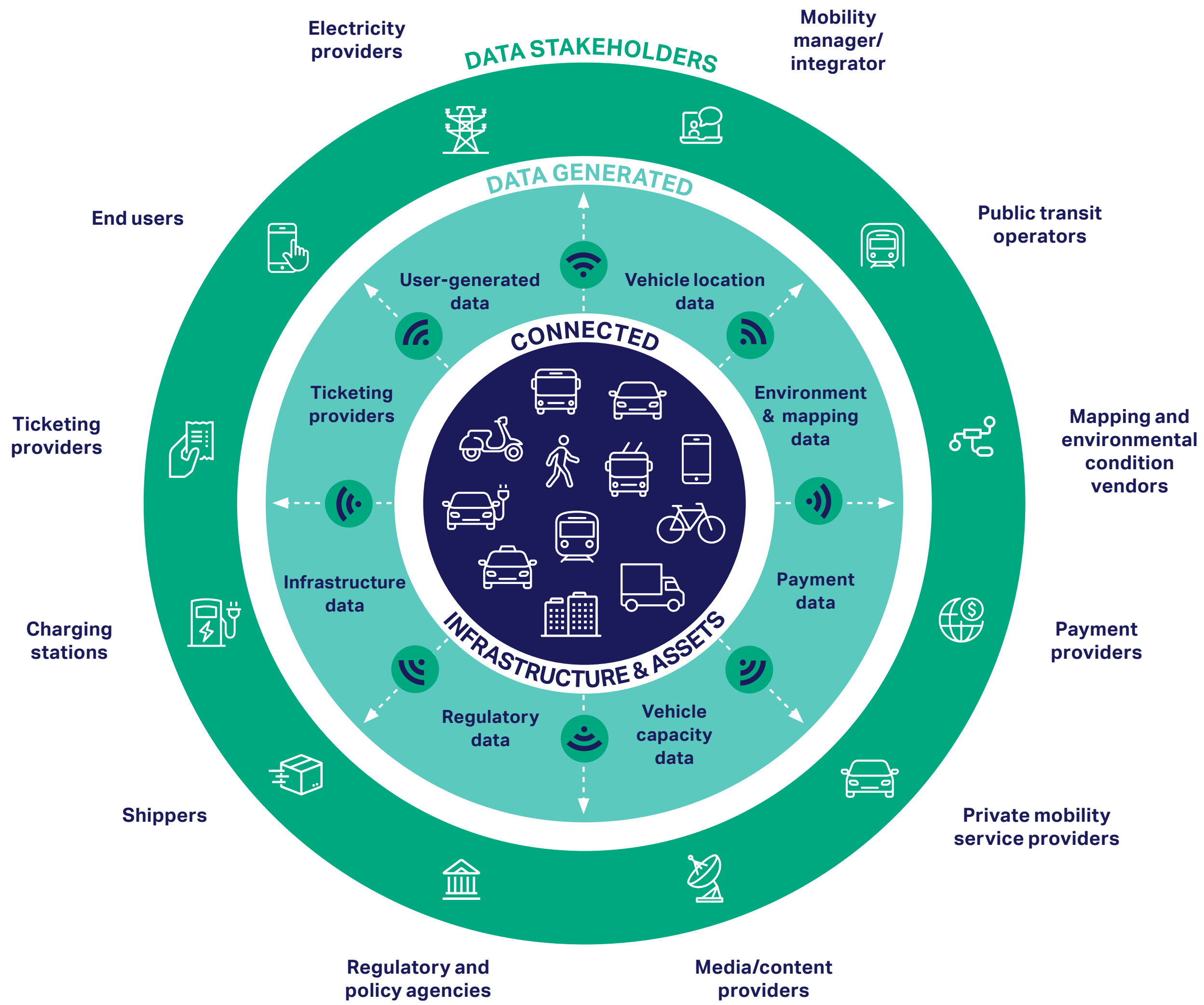
By integrating pick-up and drop-off data from ride-hailing providers and last-mile delivery companies, and by including information on traffic flow, parking, and pedestrians, private sector providers can work with city authorities to dynamically manage and regulate use of street curbs and pavements to increase traffic, reduce dwell times and improve congestion.

By merging data from vehicle telematics, connected infrastructure and drone monitoring, planners can get a granular view of the condition of infrastructure and proactively identify areas in need of upkeep by applying predictive algorithms. Similar data can be used to simulate the urban environment and help aid long-term planning.

Figure 4 illustrates a landscape view of potential stakeholders and types of data; see the appendix for more detailed, use-case specific data frameworks.

There are endless possibilities that arise from integrating mobility data – several examples are explored below. From enabling a seamless, integrated, multi-modal travel experience for users that can bring mobility to underserved populations; through to optimizing fleets that handle goods from multiple vendors, the need to have a robust and efficient means of sharing data is increasingly important.

Figure 4: Data stakeholder framework



Data-sharing models

Multiple models exist for data-sharing. In some cases, city governments play a leading role, either as a convener of different parties, as a user of shared data, or as a regulator requiring that information be made available by the private sector. In other applications, private enterprises are the key players and the exchange of data can create new revenue opportunities.

Regulated: data-sharing is mandated by government rules or legislation. Private sector operators are often required to share data with the public sector. However, there are examples where laws or regulation require some data to be made available to the public.

- Revisions to Finland's Transport Code, for example, required public transit operators to make certain data (timetables, routes, ticket prices) available via open APIs.
- In Los Angeles, micro-mobility providers are required to share information on the numbers, locations, status, and trips made by their vehicles with city authorities, enabled by APIs provided via the Mobility Data Specification (MDS). Failure to comply can result in suspension of operating licenses. Now widely adopted by multiple other cities, MDS is used primarily to regulate and control proliferation of micro-mobility modes across cities and monitor their impacts on other forms of transportation. While MDS offers a means to monitor deployment of micro-mobility modes, among other ever increasing uses, it may be limited in its ability to actively optimize fleets.

Public-private collaboration: data-sharing occurs between one or more public agencies and private sector parties for mutual benefit. Public entities may see opportunities to improve services, planning and create better customer experiences by harnessing private sector data or by allowing the private sector access to government information. Businesses may be motivated by the possibility of creating monetizable products or services, but also by the potential to reduce complexity and create standardized approaches and goodwill.

- Shared Streets, a non-profit consortium that includes public and private sector representation, aims to facilitate data-sharing and common standards by creating a set of open tools and data sets to aid cities and businesses.

Private sector collaboration: data-sharing occurs between two or more private sector parties, typically because each party believes there is monetary value or other benefits to be had in expanding the pool of available information. Sharing can be enabled by bilateral or multilateral agreements, subscription or licensing arrangements, industry consortia or direct monetary exchange.

- The Automotive Information Sharing and Analysis Center (Auto-ISAC) is an industry group comprised of automakers, suppliers and others in the commercial automotive sector. The group serves as a central repository for information about ongoing and emerging cybersecurity threats to connected vehicles.

These models are not mutually exclusive. In practice, most mobility data-sharing tends to take a blended approach.

Although there is a strong need for data-sharing, there are several barriers that currently prevent it. Data continues to be collected, managed and used by entities that may be averse to sharing it, for reasons that include competition, privacy, cybersecurity, ethical use, regulations, ownership, liability and accountability.

Overcoming these frictions to realize the value in new mobility opportunities requires alignment between multiple actors including citizens, governments, businesses, and civil society.

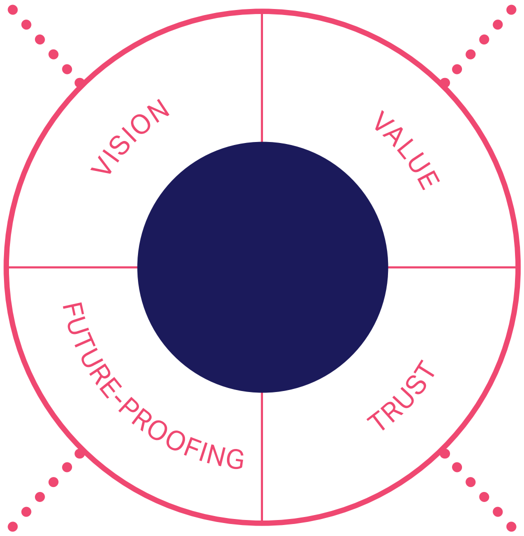
The data-sharing principles workstream of WBCSD's Transforming Urban Mobility project aims to create common ground between stakeholders, by developing a shared understanding of the problem and defining a set of principles which can help to shape a model and standards for data-sharing.

4 Emerging principles

To make mobility data-sharing principles as relevant and widely applicable as possible, they should embody four drivers: **vision**, **value**, **trust** and **future-proofing**.

VISION encompasses the end-goal for a mobility use case and the shared data that enables it

VALUE means thinking expansively and holistically about the different ways data creates benefits and for whom



FUTURE-PROOFING entails crafting principles that are sufficiently flexible to cope with a rapidly changing environment

TRUST is essential to the future of mobility, especially in the realm of shared data

EMERGING PRINCIPLES FOR DATA-SHARING

There are five principles that mobility system stakeholders should strive to adhere to in order to create data-sharing architectures that benefit all parties.

1. Data-sharing should enable all stakeholders to create and capture value
2. Data-sharing must be ethical, inclusive and unbiased
3. Data-sharing should incorporate privacy by design
4. Data-sharing should embrace cyber-security by design
5. Data-sharing should be adaptive and iterative

1 DATA-SHARING SHOULD ENABLE ALL STAKEHOLDERS TO CREATE AND CAPTURE VALUE

Allowing all parties to benefit is one of the major challenges to data-sharing.

Private sector providers often view their customer data as a source of differentiation and value creation. Public transit operators sometimes perceive alternative modes or integrated mobility apps as competitors, and don't want to provide full access owing to concerns about siphoning off passengers or under-cutting fares.

Ceding the customer relationship is a top-of-mind concern across the board. Moreover, originators of data – often individuals – and the holders of that data have different understandings of who controls what and consequently who has the right to aggregate, analyze or share it.

When data flows across disparate entities, with whom does fault lie if a breach occurs? When a trip using multiple modes is booked through a single platform with a single ticket and a single payment, who's at fault if something goes wrong? More fundamentally, what responsibility does each contributor of data to the system have to ensure its integrity?

The uncertainty surrounding these questions makes stakeholders reluctant to fully share with other entities.

Enabling data-sharing requires balancing the perceived competitive advantage of owning data with the value that could be unlocked through its sharing and aggregation. Estimating the direct and indirect value of data can be a first step, where the indirect value encapsulates all externalities – positive and negative – of a given data-sharing model. However, the indirect value of data-sharing may be hard to estimate or capture. In these cases, cities and businesses may play a proactive role in quantifying and subsidizing (or taxing) the externalities associated with data-sharing, thereby facilitating these transactions.

Additionally, cities and businesses should recognize and facilitate data aggregation, where it may create additional value either by itself, or by helping to infer new insights.

Clear data-sharing requirements will ensure that data are used in a way that benefits society and supports mobility goals without imposing overly burdensome requirements on mobility providers. Depending on the specific use-case, many approaches can be explored to ensure all parties realize value. Subscription and service fees can help recover the cost of gathering and processing data, as can different cost-sharing and charge-back structures. Other non-fiscal measures, such as mutually beneficial exchange of data or sharing talent resources for data collection, analysis, processing, storage and management across entities can also be considered.

Finally, governments should work with the private sector to create balanced regulatory structures, standardized data specifications and common reporting requirements that alleviate concerns about creating competitive advantage for some parties over others.

2 DATA-SHARING MUST BE ETHICAL, INCLUSIVE AND UNBIASED

The collection and sharing of mobility data is fraught with risk and the potential for misuse. That's why it is essential to create data-sharing models and protocols that are transparent and aligned with community expectations about right and proper use.

To begin, the means and purpose or use-cases for data-sharing should be consistent with the vision of the city – its government, citizens and businesses. But beyond that, transparent and verifiable procedures should be created to address concerns around bias, discrimination, manipulation and the repurposing and re-use of data in ways that may contradict the original consented-to intent. An independent and unbiased third-party data auditor, use of secure enclaves or the creation of data trusts can help in this regard.

Bias in data can be particularly pernicious and as data is shared across multiple entities the risks are compounded. To the extent that mobility data systematically over- or under-samples particular populations based on gender, race, socioeconomic status or other characteristics, a real danger exists that such data could lead to biased policies and outcomes.

Discriminatory levels of service, which academic research suggests are already a challenge for ride-hailing in some locations,[27] could become both more subtle and more difficult to eliminate if passenger pickup decisions are increasingly made by artificial intelligence. Such "algorithmic bias" can be difficult to identify and correct.[28]

All stakeholders need to be cognizant of these biases and work to counteract them by, for example, weighting collected data to reflect demographics and ensure quick feedback monitoring and corrective systems.

Cities and businesses must create inclusive design processes where all community organizations – citizen representative bodies, business and trade associations, academics and experts – are able to shape data-sharing models and the way they are implemented. Stakeholders must ensure that the impact of data provenance on its accuracy, reliability and representativeness is understood. That can mean radical transparency; potentially covering the source of the data; whether it was collected by humans or an automated system; how reflective it is of the target population; omissions, exclusions, or systematic biases; quality processes; and the sampling strategy used to collect the data.

Managing ethical obligations is an ongoing process with continuous engagement and collaboration with stakeholders. For example, has the context changed to such an extent that consent must be sought again from data subjects? Have data ownership or licensing issues emerged? By creating a process and a governance enabling continuous evaluation, stakeholders can generate an ongoing feedback loop to mitigate ethics risk.

3 DATA-SHARING SHOULD INCORPORATE PRIVACY BY DESIGN

Privacy issues are a significant barrier to increased mobility data-sharing. Many private sector operators are reluctant to allow access to individual data in case it is used for another purpose by another party.

Governments have a duty to safeguard public interest and can be similarly reluctant to share certain types of data. While anonymization is becoming more popular, aggregating multiple types of data from different sources raises the risk of identifying an individual.

Data-sharing models must establish and maintain trust within constituent and stakeholder communities. They must encompass reasonable expectations of privacy along with ethical and unbiased use. Gaining citizen support is critical, due to legitimate concerns that the dissemination of sensitive, personal information to parties beyond those given consent not only undermines a user's privacy rights, but also heightens the risk of unintended disclosure through data breaches or mishandling.

Accordingly, "privacy by design" principles need to be integrated into data repositories, access mechanisms and sharing protocols.

Governance structures that administer and regulate privacy frameworks can be established to build trust among citizens and stakeholders, including neutral third-parties, data trusts or other mechanisms to manage data repositories.

Additionally, the scope and purpose of data collection should be clearly defined and communicated. This could be achieved by transparently communicating the purpose of data collected specific to a data-sharing model.

This might also imply collecting anonymized data, tokenization, developing simplified and transparent models of consent-based data sharing, providing view-and-redact access for a user or citizen to their raw and processed data, secure enclaves for providing data services without access to underlying data, the partitioning of user identities and time-window limitations on data availability.

4 DATA-SHARING SHOULD EMBRACE CYBERSECURITY BY DESIGN

Cybersecurity looms over the future of mobility. While scenarios involving hacked autonomous cars grab headlines, a more immediate and pressing challenge is how to safeguard personal data – payment information, online orders, travel history, addresses and more – held by individual mobility providers.

Now imagine that data being shared across multiple public and private sector entities involved in an integrated mobility system, and the security challenges can compound significantly.

It's a common challenge of the digital age: the greatest value can only be realized by linking together disparate systems, but the points of vulnerability (and the appeal to nefarious actors) increase in parallel.

Trust in any connecting technology platform and device is the most critical element in any data-sharing platform. Without confidence in the source and use policies, data-sharing will be constricted and the integrity of the system will be impacted.

An integrated, secure-by-design approach to embed cybersecurity controls as part of the data lifecycle is key to ensuring participating systems and devices can be verified and secured. It is essential that trust can be established to verify the integrity of data. It is also essential to develop a well-defined, system-wide cybersecurity strategy that is in line with broader city objectives and that can mitigate challenges arising from the convergence, interoperability and interconnection of mobility systems.[29, 30]

5 DATA-SHARING FRAMEWORKS SHOULD BE ADAPTIVE AND ITERATIVE

The mobility landscape is evolving quickly, as is the broader environment around data handling. Increasingly, regulatory requirements such as the EU's General Data Protection Regulation (GDPR) and the California Consumer Privacy Act (CCPA) are shaping the way mobility data is handled. Cities are making data-sharing a prerequisite for mobility providers who want to operate in their markets.

A heterogenous regulatory environment across jurisdictions further requires customized approaches. As particular use-cases are replicated and scaled beyond a given urban geography, the models of data sharing and associated governance mechanisms may need to be adapted to suit local value systems and policy environment. Therefore, data-sharing models should account for differences between different geographies.

Despite progress towards creating data standards and widespread adoption of common API protocols, challenges still exist around basic data quality and formatting to enable sharing. This is often true for public sector agencies and transit operators, where budget challenges can mean grappling with legacy IT infrastructure and manual processes. Data-sharing models and implementations should also recognize legacy constructs that may inhibit future potential or limit the realization of a city's vision.

Additionally, data-sharing frameworks should also be responsive and adaptable to new evidence and information from pilots and on-the-ground implementation. Adequate feedback loops must be instituted to allow regulators and other authorities to monitor any discrepancies and adapt data sharing frameworks accordingly.

All of that makes creating flexible, adaptable and iterative data-sharing frameworks increasingly important.

A collaborative approach can result in standardized rules that work for all stakeholders. Cities and businesses should encourage a system of innovation, embracing flexible, outcome-based approaches to rule-making and the use of pilots and demonstration projects to test out new regulatory approaches.[31]

Regular multi-sector fora where citizen representative bodies, business and trade associations, labor, academics and experts can participate in shaping data-sharing models and their implementation can help create adaptability to changing conditions.

These fora can partner with regulatory bodies to ensure the development of transparent data-sharing policies in line with regulatory requirements, and the correct expression of those policies in digital policy, security and privacy settings.

5 Examining data-sharing principles through use-cases

USE-CASES

To see how these principles might be put into practice, we have explored five mobility use-cases:

1. **Integrated mobility platform incorporating multi-modal transportation systems**
2. **Real-time management and optimization of fleets**
3. **Improving access to mobility for low-income populations**
4. **Targeted infrastructure redesign and redevelopment to address road bottlenecks**
5. **Electric vehicle use via transportation network companies**

We aim to highlight some of the unique opportunities and challenges of data-sharing, and the way that applying these principles could overcome the barriers to creating a mobility system that is greener, safer, more efficient and more accessible.

1 USE-CASE 1:
INTEGRATED MOBILITY PLATFORM INCORPORATING MULTI-MODAL TRANSPORTATION SYSTEMS

Realizing true Mobility-as-a-Service (MaaS) that allows users to plan, book, pay for, ticket, and execute trips across all available modes of transportation has real potential to address the first-mile/last-mile challenge and redefine urban mobility in the long-term.

Delivering a system where people can plan, book, pay for, ticket and execute trips across all available modes of transportation supports the use of alternative modes like ride-hailing or micro-mobility (e-scooters, for instance) in order to connect with public transit.

When structured and priced appropriately, it can be used to nudge travelers to choose lower emission options and to avoid congested routes or privilege the use of less emitting modes. It can significantly improve individual travel experiences, enabling simpler, more flexible journeys.[32]

This can also be integrated with open last-mile delivery systems, further improving vehicle utilization, with the benefits of reduced congestion, pollution, and improved economic performance.

However, it also requires extensive data-sharing among many parts of the public and private sector. Achieving maximum benefits hinges on a consumer's willingness to provide personal information about where, when and how they travel. For individuals, a system like this could provide flexibility, transparency and convenience. Trips can be tailored to personal preferences, allowing users to consider different elements such as speed, cost, environmental impact and other factors. A single electronic payment and digital ticket can replace the multiple transactions typically required to make a multi-modal trip today.

Depending on how the platform is configured and operated, it could even be used to induce behavior change and modal switching. For example, by calibrating the prices of single-passenger ride-hail vehicles and mass transit during peak travel times, users can be incentivized to select options that do not contribute to congestion.

Similarly, simple changes to the framing of choices – by, for instance, making a public transit-plus- bike-share option the default option – can have a powerful influence on what individuals ultimately select.[33]

With a critical mass of users making their journey choices through a MaaS application, policymakers can begin to use those levers to impact system-level outcomes such as reducing congestion or emissions.

Data needs, challenges, and opportunities

A MaaS system requires a variety of players across multiple industries, each with their own role and data considerations (see appendix for additional detail).

There are compelling reasons to advance data-sharing for seamless intermodal mobility. Service providers such as ride-hailing companies and e-scooter operators could gain access to new customer segments by connecting their services with public transit and other modes. This can also increase their operational efficiency by providing better demand forecasting by time/location, enabling better results from planning and resource allocation algorithms.

It also makes it possible to deliver a more holistic view of travel supply and demand, and how that can vary under road conditions, weather, and time of day; which in turn enables better optimized fleet distribution and pricing.

Being a "good corporate citizen" when it comes to data-sharing can also go a long way towards creating a positive relationship with city authorities, something that new mobility providers have sometimes struggled with.

Public authorities could also gain greater visibility into on-the-ground conditions while touting improved services for their constituents. By offering open APIs, they can also foster private sector innovation and take advantage of resources (both talent and financial) that might otherwise be difficult to attract.

Of course, there are also significant barriers to expanded mobility data-sharing. Some of those are technical and require creating architecture, connectivity and interoperability just to allow data from different providers to be transferred.

The mobility field has made progress on this front, going back to the General Transit Feed Specification (GTFS)[34] more than a decade ago to more recent efforts that include the industry consortium Shared Streets[35] and the Mobility Data Specification (MDS) developed by the City of Los Angeles and now championed by the Open Mobility Foundation, a global city-led coalition focused on open-source transportation technology.[36]

While the technology challenges should not be overlooked, arguably the more pressing difficulties stem from the complicated interaction between public policy goals, private citizen rights and expectations and business needs. Those differing priorities manifest in many of the ways common to mobility data-sharing overall: competitive concerns, privacy and security issues and uncertainty over risk and liability.

Data-sharing in practice: Helsinki

Helsinki, Finland, is arguably amongst the leaders in seamless intermodal mobility and MaaS.

Residents can use the Whim app to plan and pay for public and private transportation within the city – train, taxi, bus, car-share or bike-share.[37] Users select a destination, then select the preferred mode of travel – or a combination if no single mode covers the entire journey – and go.

Prepayment is possible through a monthly mobility subscription, but so is a pay-as-you-go option using a linked payment account. The goal is to make it so convenient for users to get around that they opt to give up their personal vehicles for city commuting, not because they're forced to but because the alternative is more appealing.[38]

From a data perspective, a key factor enabling the Whim app has been Finland's recent laws requiring open APIs for all transport services, public and private.[39] The law only requires open data however and cannot compel any particular operator to join Whim or any other integrated mobility service. Some private ride-hailing providers have yet to join the platform, limiting the scope of services available to users.[40]

Data-sharing principles for seamless multi-modal mobility

While it is unlikely that a single set of policies, standards and protocols will be universally applicable and solve all of the challenges around data-sharing, we can apply the principles set out here to ease implementation of seamless multi-modal mobility.

Data sharing must be ethical, inclusive and unbiased.

Start with the end in mind and measure progress towards those outcomes. A seamless integrated mobility system can create numerous benefits for multiple stakeholders, but it cannot be all things to all people. Trade-offs exist between, for example, offering every individual their most-preferred trip option, and optimizing the entire system to reduce congestion.

Stakeholders should align on the outcomes for prioritization, the available levers to produce those outcomes, and how to measure success. Is the aim to reduce gridlock? Encourage people to use public transit or active modes of transport? Offer the most seamless and convenient trip possible for each user?

By forging broad agreement on priority goals at the outset, both the public and private sector can make more informed choices about what, how and when data will be shared. A non-focused approach towards data sharing may offer scant benefits at huge expense to most stakeholders.

Data-sharing should enable all stakeholder to create and capture value.

In reality, mobility data has a wide array of combinations and permutations. It can be highly aggregated or highly individualized. It includes everything from trip origins and destinations to the location of potholes to current weather to credit card information. To get a solid footing in the discussion around mobility data-sharing, we have to adopt a more nuanced and perhaps, somewhat complicated vocabulary and parse out the added value from these diverse data types and datasets.

Aggregating mobility data also means acknowledging that not all data is created equal and that not all data is equally valuable. The mantra that "data is the new oil" fails to recognize that much data is arguably worthless, at least in monetary terms. Data exchange for mutual benefit on a quid-pro-quo or emulated value basis may be more effective than pure data monetization.

Private sector mobility providers would do well to critically evaluate their own data needs and where true differentiation occurs before reflexively rejecting sharing information for fear of losing a competitive edge. While still early days, some evidence suggests that sharing data to create a more integrated user experience can redound to the benefit of all parties.

In Denver, Colorado (USA), for instance, Uber users can now book tickets on Regional Transportation District (RTD) trains, an initiative that has increased RTD ridership, and the proportion of Uber rides starting or ending at a train station has risen 12 percent.[41]

Data-sharing should incorporate privacy by design.

Anonymize and aggregate wherever possible. The temptation is often to seek the most granular, lowest-latency data, even if the application or use-case in question does not require such detailed information.

As the US National Association of City Transportation Officials (NACTO) notes, "Good data management practice begins with being clear about what questions are being asked and what information is necessary to answer those questions. For both public and private sectors, preparatory work is essential to get the right data and to avoid capturing unnecessary data."[42]

With the question clear, entities should seek the least personally identifiable data possible. Doing so – and communicating accordingly – can help players across the mobility spectrum win user trust. Stakeholders should also consider employing a trusted third-party to serve as a clearinghouse and fiduciary authority for mobility data.[43]

Data-sharing frameworks should be adaptive and iterative.

The data-sharing architecture of an integrated mobility platform should be sufficiently flexible to accommodate new types of information and the new modes and business models that will emerge. To that end, players should avoid closed systems and "walled gardens" where possible.[44] Pilot efforts can help cities and other stakeholders better understand the particularities of data sharing in the context of shared multi-modal transportation, specifically the needed governance structures, from which they can refine and build more robust rules for accountability, enforcement and exchanges.

2 USE-CASE 2:
REAL-TIME MANAGEMENT AND OPTIMIZATION OF FLEETS

Fleets – groups of vehicles owned or operated by a common entity – play an increasingly important role in urban mobility, both for passengers and for goods.

Several new types of fleets have joined traditional taxis and buses, including car-sharing vehicles, ride-hailing services, micro-transit (dynamic shuttles), and micro-mobility (shared bikes and e-scooters). E-scooter providers field fleets of hundreds or thousands of vehicles in the cities they operate in. Estimates vary, but there are at least several million ride-hailing drivers, and while few of the associated vehicles are owned by the companies operating the service, they nonetheless share many common fleet management concerns.[45]

The movement of goods is increasing in importance, as the rapid growth of e-commerce and to-your-door delivery has led to more carrier fleets in city streets. The combined impact is staggering – in China for example, daily parcel deliveries are on track to hit 145 million by the end of 2020, nearly tripling from 57 million in 2015.[46] All of those delivery vehicles have a significant impact on congestion and emissions.[47]

Many of these diverse fleets already rely on a wealth of self-generated data to streamline operations. Even greater benefits are possible if the data can be shared between parties.

For example, cities could have greater visibility of real-time conditions and a more holistic picture that accounts for (and differentiates between) the movement of people and goods. In turn, that can enable them to better predict and manage congestion, curb usage and other outcomes.

For personal mobility providers – including ride-hailing, car-sharing, and micro-mobility services – integrating their vehicle and trip data with others' (such as public transit schedules) can help to better match the distribution of their fleets with current and anticipated demand, leading to higher utilization, fewer empty miles, reduced dwell times and greater customer satisfaction. Academic research suggests that by coordinating drop-off/pick-up locations across modes – even if the shift in location is only 1 kilometer – providers could reduce their required fleet size by up to 12 percent.[48]

Such approaches may open doors for a higher proportion of shared or partially shared journeys, further increasing efficiency. For last-mile freight carriers, optimizing with data on road, traffic and weather conditions along with vehicle locations and cargo can yield greater efficiency, improved visibility for both the company and consumers, and better-informed predictive maintenance (vehicles subject to stop-and-go city traffic may need more frequent attention, for example, as will those often traveling pothole-ridden roads).[49]

Data needs, challenges and opportunities

While the precise data required to achieve dynamic fleet management and optimization will vary based on the fleet in question, in general stakeholders will require:

- Trip origination and destination for the focal fleet and related fleets (e.g., micro-mobility providers targeting the "last mile" will need real-time data on bus arrival time, location and passenger numbers)
- Current vehicle locations for the focal fleet
- Current road and environmental conditions (traffic, construction, weather, etc.)

Competitive concerns, privacy and security issues can inhibit data-sharing for fleet management. For both the movement of people and goods, providers might be understandably reluctant to share information on vehicle location and routing for fear of providing potential competitors with insight into their operations.

Even more fundamental can be the data collection in the first place. The freight industry is highly fragmented and many smaller (and even some larger) players are just beginning their journey towards digitization. Paper logs and manual processes are still the norm in many areas of the industry.[50]

Accordingly, simply creating the systems to collect the requisite data can be a challenge.

Data-sharing in practice: Portland

Sharing fleet data can not only enable providers to better manage their vehicles, it can also provide cities with important insights into the way citizens are using different mobility options; and the impacts they have on infrastructure and key policy outcomes.

The city of Portland, Oregon (USA), recently completed a pilot e-scooter program. Among other criteria, mobility providers were required to share data with the city, including real-time availability, trip starts and destinations, routes and safety information.[51]

The data enabled the city to monitor compliance with another program requirement – that certain numbers of vehicles be deployed in lower income neighborhoods in East Portland – and ultimately helped the city create one of the most comprehensive and detailed reports on the impacts of shared scooter use.

Those findings helped inform a second, expanded pilot program in 2019-2020 with similar data-sharing requirements,[52] which will ultimately inform the city's policy toward micro-mobility.

Data-sharing principles for fleet management and optimization

Data-sharing should enable all stakeholders to create and capture value.

Value derived from shared data should be distributed. Many governments employ "land value capture" as a way to recoup investment in public infrastructure. In short, as infrastructure investments increase property values, authorities seek to capture some of that value via higher property tax assessments. Similarly, incremental value is created when shared data allows for improved fleet management. To incentivize that sharing, and to overcome reluctance by some parties to release what they may view as proprietary information, members of a data-sharing consortium should establish agreed-upon approaches for valuing and distributing amongst themselves all the externalities associated with integrated data.

Data-sharing must be ethical, inclusive and unbiased.

In this context, that can entail optimizing across fleets, not just within them. Nearly every entity that oversees a group of vehicles is already deeply engaged in getting the most from its own fleet and sharing data across providers can improve some of those outcomes. But just as with personal travel choices, optimizing for the individual can lead to sub-optimal results for the collective. Fleet managers need to engage with their counterparts to improve the "system of systems" that is urban transportation, in a way that allows everyone to benefit.
It is likely that to do this at scale and depth will require governance or even a licensing-related mandate from public sector authorities. This should not be confused with central planning by public authorities.
To facilitate data-sharing among fleet managers who may also be competitors, stakeholders should consider turning to a trusted third party. Establishing an "information fiduciary" or data trust with a duty to act in good faith could be one approach.[53, 54]

Data-sharing frameworks should be adaptive and iterative.

The urban mobility environment is dynamic. Fleet managers will need to re-evaluate established processes for determining fleet size, composition, and distribution.
As new vehicle form factors emerge and new types of data become available, once state-of-the-art methodologies can quickly become obsolete.[55]

3 USE-CASE 3:
IMPROVING ACCESS TO MOBILITY FOR LOW-INCOME POPULATIONS

Access to affordable, reliable, safe transportation is often a significant challenge for low-income populations and it can have an impact on economic outcomes.

Lower incomes and "transport poverty," which encompasses a range of conditions, from having literally no viable options, to having to spend exceptional amounts of time commuting, to having unsafe or unhealthy travel,[56] is associated with traveling less overall, lower rates of car ownership,[57] reduced likelihood of obtaining and keeping a job,[58] and a lower sense of subjective wellbeing.[59]

In one of the most careful studies of its kind, shorter-commute times were one of the strongest predictors of inter-generational social mobility.[60] For those lower-income households that do own a car, those vehicles tend to be older, have worse fuel economy and pollute more than average.[61]

In some markets, the poor must dedicate significantly greater proportions of their income to transportation than the rich.[62]

New research using geolocation "big data" finds that clusters of physical interaction in cities – enabled by mobility – are strongly associated with economic growth and opportunity.[63]

Many approaches have been explored to try to improve mobility access for the poor. Many of these have focused on affordability by offering subsidized or reduced fares for public transit. However, an integrated approach that combines multiple forms of travel and targeted financial incentives are key to extending access to low-income communities.

Linking ride-sharing services with public transit, for example, can help address the first-mile/last-mile problem that leaves many people cut off from using buses and subways.[64] The new wave of micro-mobility services (dockless bikes and e-scooters) could be a powerful tool to extend access to traditionally underserved groups. Limited survey data suggests that support for e-scooters tends to be highest among lower-income users.[65]

Additionally, subsidizing multi-modal mobility services or provision of direct financial incentives for mobility for low-income populations may be explored.

Additionally, cities are also increasingly requiring providers to meet minimum service criteria for certain communities as a condition for receiving an operating permit. The city of Oakland, California (USA), for example, stipulates that scooters should be "distributed equitably" with over 50 percent placed in the city's designated "communities of concern."[66] That requires a greater degree of data-sharing between the public and private sector; in Oakland, scooter operators are also required to provide "real-time access to data showing the location of all their scooters [sic]" to enable compliance monitoring.

Data needs, challenges and opportunities

Simply understanding the mobility needs of low-income communities presents a data challenge of its own. There are multiple dimensions to the problem and multiple ways of measuring them.[67]

Basic data on low-income populations tends to be less available and less accurate than for the population as a whole, especially in the developing world, which complicates the challenge.[68]

The data required to effect policies for low-income communities will vary based on the approach taken, but in general it includes:

- Geographic and demographic data, including the physical distribution of household incomes (or other measures of wealth or need), distance from transit stops and job accessibility
- Trip origination/destination data
- Modal choice data, including incidence of car ownership, trip distribution across different modes and proportion and type of multi-modal trips
- Trip cost data

Some of this data, such as personal income or employment status, is highly personal and needs to be treated with the utmost care (as per the privacy by design principle).

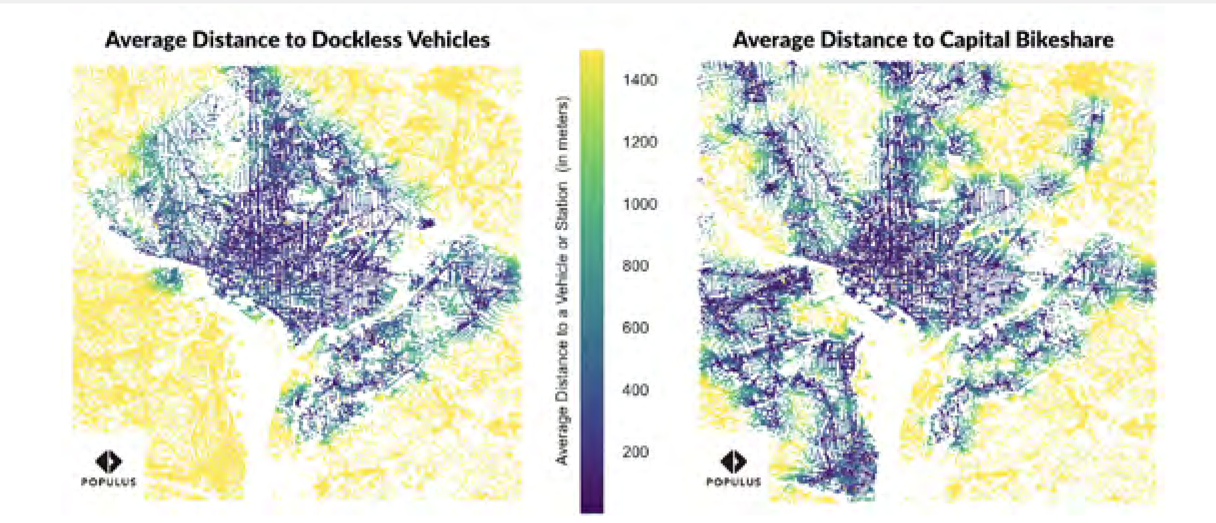
Data-sharing in practice: Washington, DC

Understanding how new mobility services impact disadvantaged communities is one of the most pressing questions facing transportation leaders. Car-sharing, ride-hailing, docked bike-sharing, dockless e-scooters and autonomous vehicles have all been touted as aides to low-income travelers – or condemned for either not doing enough or worsening inequality.

To get a better understanding of how these options are used, mobility data firm Populus worked with Washington DC's District Department of Transportation to assess the city's dockless micro-mobility options.

Washington DC's program mandated granular data-sharing by micro-mobility providers, including GPS-based location of vehicles and trip data. Populus was able to combine that information with survey-derived demographic and other information on mobility patterns to reveal that dockless modes were more available than their docked counterparts, including in underserved areas, and that minority users had adopted dockless vehicles at significantly higher rates than the city's docked bikeshare program (figure 5).[69]

Figure 5: Comparison of the dockless program to Capital Bikeshare stations



Source: *Populus,* Measuring Equitable Access to New Mobility.

Data-sharing principles for improving access to mobility for low-income populations

Data-sharing should enable all stakeholders to create and capture value.

Extending or improving mobility services to low-income communities can be costly. Both the public and private sector need to think creatively about how to design financially sustainable solutions and preserve the ability to monetize data.

In some cases, this may entail subsidies or other financial instruments such as tax credits, credits for road-use, or congestion fees from local governments to mobility service and public transit operators, or direct incentives to low-income populations. Cities may also require operators to service disadvantaged communities in exchange for being able to do business in more lucrative neighborhoods and routes.

Data-sharing agreements should be constructed to preserve the ability of data creators/owners to monetize that information.

Data-sharing must be ethical, inclusive and unbiased.

"Low-income" is not a monolith, and different cities and neighborhoods will have different needs. The priority in some areas may be affordability, while in others it will be commute times, or ensuring access to public transport. The community and relevant stakeholders need to be clear on the outcomes they are trying to realize, and how they will be measured.

Traditional data collection approaches can leave communities and key demographics under-represented, which can lead to bias in the policies, services and algorithms informed by that data. Low-income users may be less visible in standard collection methods for a variety of reasons—they may lack smartphones or other forms of connectivity, may be unbanked or may have varied legal status. Stakeholders need to proceed with special care to ensure their data represents the entire community. That might mean re-weighting data sets to match known demographics, for instance.

Avoiding biases also requires that data that is required for offering mobility choices to these groups be distinguished and separated from the data that is used to evaluate these policy outcomes for individuals.

Data-sharing should incorporate privacy by design.

Often, demographic data for low-income populations may originate from government databases and census surveys that can often link to other sensitive personal information such as tax status and credits, health, education, legal and criminal information about individuals. Purging additional data that is outside the scope of mobility service offerings, anonymization, temporal and spatial aggregation of personal data and data trusts can help protect privacy of individuals and build long-term trust in such offerings.

Data-sharing frameworks should be adaptive and iterative.

The mobility landscape is evolving rapidly. New modes and services have the potential to significantly improve access for underserved communities but could also exacerbate existing disparities. As self-driving vehicles begin to enter city streets, ubiquitous autonomous vehicles could cannibalize public transportation – which is still the most efficient means of moving people in cities.[70] This could exacerbate the funding and infrastructure challenges that transit operators face and create a two-tier transportation system.
Having an agreed-upon data-sharing framework and key metrics to gauge progress on low-income mobility will be key to assessing how new modes and services impact the most vulnerable users.

4 USE-CASE 4:
TARGETED INFRASTRUCTURE REDESIGN AND REDEVELOPMENT TO ADDRESS ROAD BOTTLENECKS

"Flexible" and "adaptable" may not be words that are top of mind when thinking about transportation infrastructure. The traditional design, construction, operation and maintenance of roads, bridges and other physical infrastructure has been capital intensive, often with long lead times and a limited ability to shift footprint and usage as mobility patterns evolve over time.

There is an opportunity to inject a degree of adaptability into the infrastructure redesign and redevelopment process, by harnessing disparate sources of data to create a higher resolution, near real-time picture of how the built environment is used. That can in turn lead to multiple short – and long-term benefits.

On a day-to-day basis, it can allow city transportation officials to rapidly or preemptively respond to traffic bottlenecks by, for example, adjusting traffic light timing, changing on-street parking rules, or calibrating tolls on high-use thoroughfares.

In the longer run, a more comprehensive picture of urban infrastructure informed by integrated data can be used to better plan future projects, identifying where critical chokepoints occur (and why) and enabling sophisticated simulations that let city planners better understand the consequences (intended and – crucially – unintended) of different choices. The net result can be reduced congestion, increased throughput, lower emissions from vehicle idling and safer streets. In pilot efforts, AI-enabled smart traffic signals cut idling times and the number of stops by 41 and 31 percent, respectively.[71]

Planners may also choose to design new infrastructure for flexibility. For example, cities may choose to design urban channels in such a way that the allocation of space between pavement, bike lane, bus lane, car lanes and green space is relatively flexible, with junction design to allow reallocation with relatively low cost. Beyond increasing traffic flow over time, such planning is based on the principle that city designs evolve over time, and such transitions must be as frictionless and cost-effective as possible. Using scenario-based approaches, cities can work backwards from expected needs and build infrastructure that incorporate current realities, constraints and budgets with an eye to the future.

Data needs, challenges and opportunities

The most obvious source of data for infrastructure redesign and redevelopment comes from the infrastructure itself. In some places, observational surveys of intersections and roadways – essentially, city employees standing on the street counting vehicles – are still the default source of truth about urban infrastructure. But authorities are increasingly deploying smart, connected infrastructure that can communicate real-time conditions, from traffic signals to embedded road sensors and smart streetlights.

Internet of Things (IoT)-equipped infrastructure is one source of data, but this can be limited owing to the costs of retro-fitting assets with sensors, as well as constraints on the types of data that can be collected and the extent of coverage possible. Increasingly, data from other sources – like connected cars, e-scooters, and smartphones – can be used to augment and improve the picture.

In Louisville, Kentucky (USA), and other cities, aggregated scooter use data shared by providers via APIs shows city leaders where and when those vehicles are being utilized. This in turn informs their plans for bike lane infrastructure.[72] Vehicle-to-infrastructure (V2I) connectivity can not only help with safety and throughput, it can also help identify road issues. For instance, in-vehicle sensors can transmit data on vertical wheel movement and vehicle acceleration to gauge things like pothole size and location.[73]

There are several challenges harnessing this data for infrastructure redesign and redeployment. From a collection standpoint, a mobility data standard has yet to take hold, which can make basic interoperability a challenge.

Several recent initiatives aim to address this gap, including the Mobility Data Specification (MDS) discussed earlier, the Open Mobility Foundation, and Shared Streets among others.[74]

Lastly, having the capabilities and processes in place to make use of diverse infrastructure data for planning and redesign can be a formidable challenge for city transportation departments, some of which lack the necessary technical capacity. Tapping third-party mobility data vendors can help provide those missing capabilities, but it then risks a loss of oversight and control by public sector authorities and incentivizes gaming by certain actors.

Data-sharing in practice: Copenhagen

In an effort to reduce carbon emissions and encourage alternatives to car use, Denmark's capital installed nearly 400 intelligent traffic signals linked to a broader traffic management system.[75] City buses are able to communicate with the system in real-time, sharing their position and information about their capacity and schedule. To speed them up, the traffic signals can extend green lights by up to 30 seconds. The signals' cameras can also detect and give priority to cyclists.

Data-sharing principles for targeted infrastructure redesign and redevelopment

Data-sharing should enable all stakeholders to create and capture value.

When it comes to sharing data for infrastructure redesign, finding a direct line-of-sight to enterprise value can be difficult for private sector operators. Stakeholders, particularly in the public sector, should consider ways to incentivize or regulate data-sharing. The value created can also rebound to private sector providers; easing traffic bottlenecks can also benefit ride-hailing providers and delivery companies.

Data-sharing must be ethical, inclusive and unbiased.

Few would disagree with the goal of creating more adaptable and responsive infrastructure. But even with the best data, there can be difficult tradeoffs around where, when, and for whom roads, curbs, sidewalks, and other physical assets should be redeveloped. Stakeholders across the data system should align priorities – whether they be improving throughput, increasing safety, or inducing mode shift away from personal cars – and use those priorities to inform the type of data-sharing required to effect change.

Data-sharing should incorporate privacy and cybersecurity by design.

Communicate both the positives and the costs of inaction. How and where infrastructure is created can have an enormous impact on local communities. Businesses can thrive or suffer based on changes to parking rules or the duration of new construction projects. Land values can soar or plummet. To win and keep community trust for data-driven, targeted infrastructure redesign, public and private sector leaders need to convince local stakeholders that the long-term benefits will ultimately be worth the near-term costs.

Data-sharing frameworks should be adaptive and iterative.

Futureproofing physical infrastructure is hard, almost by definition. But leaders should consider how they might construct roads and other infrastructure in ways that maximize flexibility and the potential to repurpose assets should the need arise. That could mean using digital signage and lane markers to transition from, for example, an open vehicle lane to one that is dedicated to high-speed buses or bikes and scooters.

5 USE-CASE 5:
ELECTRIC VEHICLE USE VIA TRANSPORTATION NETWORK COMPANIES

Electric vehicles (EVs) have advanced significantly in recent years. Technology improvements and longer vehicle ranges make them a more attractive and viable option in more contexts.

Battery costs – the most significant incremental cost in EVs – have plummeted, falling more than 80% since 2010. Governments have announced policies to incentivize EV ownership, discourage internal combustion engine (ICE) vehicles, or both. Nearly every global automaker has announced plans to expand their EV offerings. [76]

Despite these developments and rapid growth in adoption in annual terms, EV penetration in the overall vehicle fleet remains small at just 0.5% of the global fleet.[77] More widespread EV adoption could contribute to cleaner air in cities, reduced greenhouse gas emissions and even hasten the arrival of fully autonomous vehicles.

One promising opportunity to increase EV use is via transportation network companies (TNCs, often ride-hailing or car-sharing services). In addition to their environmental benefits, electric vehicles offer several advantages for TNCs.

Despite their higher upfront cost, they often have lower per-mile operating costs. Electric drivetrains are much simpler than ICE vehicles, which reduces maintenance expenses[78]—this is a key consideration for vehicles that are often used much more than their privately-owned counterparts. Additionally, EVs tend to perform better than ICEs in terms of range and efficiency at lower urban speeds or in frequent start-stop traffic conditions.

Data needs, challenges and opportunities

From a strict data-sharing perspective, to make that opportunity a reality TNCs and their drivers would need access to multiple streams of information across several players. Assuming sufficient charging infrastructure exists, comprehensive, real-time data on the location, availability, and speed of charging stations – matched with anticipated demand and range needs of the vehicle fleet – is key to making the system work.

Multiple charging standards exist, as well, so ensuring compatibility between infrastructure and vehicles demands sharing data across charging providers and TNCs, as well. Location-specific charging demand data should also be shared with electricity providers and utilities to prevent local brownouts and possibly to enable dynamic grid management.[79]

Lastly, as multiple cities move towards transport decarbonization through the creation of low- and zero- emission zones, TNCs will need the ability to feature EV options in their applications. TNCs may potentially need to price them differently as well order to ensure uptake, although many of those capabilities may not require cross-stakeholder data-sharing.

Data-sharing in practice: Uber's EV Champions Initiative pilot

In June 2018, Uber launched a pilot effort aimed at encouraging drivers to adopt EVs in seven cities across the US and Canada — Austin, Los Angeles, Montreal, Sacramento, San Diego, San Francisco and Seattle.[80] The program involved several non-profit and expert organizations, electric utilities and academic organizations. Drivers were provided with educational resources about rebates and tax incentives, along with in-app features to counteract range concerns. Some markets also received free fast-charging and financial incentives for using an EV. Riders were also notified that their driver would be using an EV.

Data-sharing principles for electric vehicle use via transportation network companies

Data-sharing should enable all stakeholders to create and capture of value.

EVs can serve as a differentiator. Growing segments of the population in many countries are becoming increasingly environmentally conscious, particularly on issues relating to the climate crisis.[81] By enabling widespread adoption of EVs, multiple stakeholders – from TNCs to charging providers and utilities and retailers – have an opportunity to frame their enterprises as good stewards of the environment.

Data-sharing must be ethical, inclusive and unbiased.

Prioritize data accuracy and transparency. “Range anxiety” and other reservations are still issues for EV drivers.[82] Providing users, whether they are ride-hailing drivers or car-sharing customers, with trustworthy and accurate data on the range of their vehicle relative to their upcoming trip and the location of the nearest charging point, is essential to overcoming anxiety. Even a single negative experience could significantly hinder a user’s future willingness to utilize an EV.

Data-sharing should embrace cybersecurity by design.

No single player can create EV-based on-demand mobility. Bringing together multiple stakeholders, including TNCs, charging hardware and software providers, electricity generators, retailers and real estate owners to work toward a common goal is an important endeavor.

Governments eager to encourage EV adoption can play an important convening role as well. But concerns about grid vulnerability and related cybersecurity concerns could scuttle multi-stakeholder arrangements.

Data sharing frameworks should be adaptive and iterative.

Prepare for tomorrow’s charging technology.

Relatively slow, Level 1 and Level 2 alternating current (AC) charging is the most common means to recharge EV batteries today. Charging points are typically located in individual homes and are meant to charge personally-owned vehicles for long stretches, often overnight.

However, direct current (DC) and newer breeds of ultra-fast chargers, at conveniently located multi-purpose hubs, are increasingly becoming more densely available and are likely to have greater applicability in the context of commercial fleets.

Where possible, stakeholders should work together to agree on standardized and inter-operable charging technology.

6 Conclusion

The last decade has seen tremendous shifts in the mobility landscape, and the pace of change seems likely to accelerate in the coming years.

Harnessing those developments to address some of our most pressing societal challenges will hinge on numerous factors, from regulation and consumer attitudes to the pace of technological development itself.

Equally important will be the ability to share diverse data safely, securely, and transparently. No single actor working in isolation can realize the promise of the future of mobility. It can only be achieved through the hard and sometimes uncomfortable work of deep collaboration. That collaboration is pinned to shared data, and every stakeholder of the mobility ecosystem has a role to play to enable change.

The mobility data-sharing principles outlined in this document are part of an ongoing and evolving dialogue about transportation data. We have qualified them as emerging principles, and we fully expect collective thinking to evolve along with the broader mobility landscape, societal expectations, and the regulatory environment.

Nonetheless, we hope that stakeholders from all corners will find them a useful starting point to guide the processes aiming at leveraging the immense potential of technology as they look to advance toward the future of mobility.

Appendix

1 USE-CASE 1

DATA STAKEHOLDER FRAMEWORK – MULTI MODAL TRANSPORT

TRIP INITIATION

- User location
- Intended destination
- Historical data (preference)
- Traffic condition data
- Weather update data
- Public transit delay data
- Road network disruptions
- Demand/ supply data on transport options
- Pricing

TRIP SELECTION

- Trip request dispatched
- Data on pick up location and approximate time
- Issue of single ticket

JOURNEY

Departure

- Asset (transport) location data
- Route plan data/ signposts
- Boarding confirmation data

In-transit

- Personal entertainment preferences
- Ride-hail vehicle capability data
- Content/ad data

TRIP COMPLETION

- Payment details
- Transaction clearance
- Payment distribution

2 USE-CASE 2

DATA STAKEHOLDER FRAMEWORK – REAL-TIME FLEET MANAGEMENT

TRIP INITIATION	TRIP SELECTION	JOURNEY	TRIP COMPLETION
User/pick-up location	Data on pick up location and approximate time	Transport location data	Payment details
Intended destination	Request dispatched	Route plan data/ signposts	Transaction clearance
Traffic condition data	Vehicle selection	Boarding/ pick-up confirmation data	Payment distribution
Weather update data		Dynamic road/traffic condition data	Delivery confirmation
Vehicle capability data (size,load capacity)			
Public transit schedule data			
Demand/ supply data on transport options			
Pricing			
Road network disruptions			

3 USE-CASE 3

DATA STAKEHOLDER FRAMEWORK – LOW INCOME MOBILITY

TRIP INITIATION	TRIP SELECTION	JOURNEY	TRIP COMPLETION
User needs (budget, accessibility)	Trip request dispatched	Transportation location data	Payment details
User location	Data on pick up location and approximate time	Route plan data/ signposts	Transaction clearance
Intended destination	Issue of single ticket	Boarding confirmation data	Payment distribution
Public transit data			
Vehicle capability data (accessibbility, passenger load)			
Demand/ supply data on transport options			
Traffic/ environment condition data			
Pricing			
Road network disruptions			

4 USE-CASE 4

DATA STAKEHOLDER FRAMEWORK – INFRASTRUCTURE REDESIGN & REDEVELOPMENT

INFRASTRUCTURE	PUBLIC TRANSPORT	PRIVATE TRANSPORT	SMARTPHONE DATA
Smart traffic signals	Smart public transport (buses, trains)	Connected cars	Smartphones data
Embedded road sensors		E-scooters	
Smart street lights			
Smart public buildings			
Intelligent toll systems			
Traffic condition data			
Weather update data			

5 USE-CASE 5

DATA STAKEHOLDER FRAMEWORK – ELECTRIC VEHICLE USE

TRIP INITIATION

Vehicles
- Battery capacity of the EV
- Compatibility of the EV
- Ownership data of the EV

Charging station
- Location/size of charging stations
- Charging capacity of the stations
- Compatibility with different EV
- Charging speed
- Data of electricity providers & utilities

TRIP SELECTION
- User location
- Intended destination
- Traffic/ environment condition data
- Pricing

JOURNEY
- Transportation location data
- Route plan data/ signposts
- Boarding confirmation data

TRIP COMPLETION
- Payment details
- Transaction clearance
- Payment distribution

Endnotes

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